

Photos: YVES GUILLOTIN

Inside the leviathan

German plasma technology in use in the world's largest liquefied natural gas tankers

Two of the largest liquefied gas tankers in the world are soon to be launched at the Aker Yards shipyard in St. Nazaire in France. As part of their completion an extremely costly insulation process was carried out in their interiors. This was only made possible by the use of a German plasma technique.

Natural gas is steadily gaining in importance as a source of energy. The world energy markets are increasingly replacing the primary energy resources of petroleum and coal with natural gas which is a distinctly more environmentally friendly alternative for energy production. In order to transport gas by ship from producing countries, which are usually quite remote, it is cooled down in liquefying plants to minus 163 degrees centigrade and in this way it is condensed to one 600th of its original volume. At its destination the liquefied natural gas is gasified once again and fed into the gas supply network.

Two of the largest natural gas tankers in the world are soon to be launched in the docks of "Les Chantiers de l'Atlantique". This is a shipyard with rich traditions (now renamed "Aker Yards") in St. Nazaire in France. As part of their completion an extremely costly insulation process was carried out in their interiors. This was only made possible by a German plasma technique.

The shipyard which built famous ships like the "Ile de France" and the biggest cruise liner in the world, the "Queen Mary 2" was commissioned at the end of 2003 by the energy giant Gaz de France to build three LNG (liquefied natural gas) membrane tankers: the EnergyY and the two sister ships Provalys and Gaselys. The latter two - measuring 300 metres in length, 42 metres in width and 50 metres in height - are intended to be the largest liquefied gas tankers in the world.

For the insulation of the tankers the novel CSI insulation technology developed by GTT (Gaztransport Technigaz) is to be used for the first time. This allows the layers of insulation to be combined and their thickness reduced so that the capacity of the tanker can be increased by 8,000 cubic metres. Ensuring an absolutely tight seal in the bonding of the new composite insulating panels directly to the inner hull of the ship is the objective of the commission.

Openair Plasma process

In order to meet this requirement Aker Yards - after extensive tests on various systems - bought twenty robot-controlled units costing about one million Euros from Plasmatrete GmbH, Steinhagen, in the spring of 2005. Plasmatrete is the world market leader in atmospheric-pressure plasma. The internationally patented Openair Plasma process is used for the ultrapure cleaning, activation and coating of the surfaces of materials.

The membrane tankers, Provalys and Gaselys, each have four separate tanks having a total volume of 153,500 cubic metres. The membrane systems developed by GTT are not self-supporting; the double skin of the ship's hull is the actual structure supporting the tanks. The storage tanks are largely adapted to the shape of the ship and integrated into the hull. Two membrane layers, referred to as barriers, serve to provide sealing and security.

Four insulating layers

The structure of the novel CSI insulating layer consists of four levels. The inner, impermeable metal membrane forms the actual cargo tank, i.e. it is in direct contact with the liquefied gas. This first barrier consists of 0.7 millimetre thick invar steel, an alloy having a very low coefficient of thermal expansion. Behind this is an insulating layer composed of plywood and a 10 centimetre thick layer of expanded polyurethane foam. This is followed by a thin Triplex sheet, the key characteristic of the CSI technology, because hitherto in membrane tankers the second barrier was also made of invar steel. The sheet consists of two outer glass-fibre components and an intervening aluminium layer. This composite material together with the flexible Triplex strips to be applied layer forms the second watertight barrier. Between the Triplex sheeting and the inner metal hull of the ship there is another 20 centimetre thick layer of expanded polyurethane.



Giant LNG membrane tankers transport liquefied natural gas across the oceans

Precision pretreatment

The insulating composite material is adhesively bonded directly to the inside of the double metal hull of the ship. Both barriers, but especially the insulating layer of the second barrier, are intended to prevent the extremely cold liquefied gas from coming into contact with the steel wall of the ship's hull which would cause it to become brittle due to the very low temperature.

Surface treatment with Openair Plasma ensues here at the level of the second barrier. The aim is to prepare for the process of bonding thousands of flexible Triplex strips. The strips are 30 centimetres wide and in each tanker have a total length of 40 kilometres. With their help the edge seams of the 1 by 3 metre insulating sheets are bonded over with a two-pack epoxide adhesive to provide a perfect seal.



The construction work requires costly scaffolding systems

"The ambient atmosphere in a test laboratory does not at all match the real situation," says Yves Pelpel, Aker Yards Contract Manager, in an interview, "the environmental conditions in shipbuilding are more like those in a building site with concrete being poured." The installation of expensive ventilation systems and air-conditioning units in the interior of the tanks is one prerequisite for troublefree bonding processes, but a still more decisive factor is the precision pretreatment of the surfaces of the bonding points.

Aker Yards tested various methods, but neither chemical processes nor flame treatment of the surfaces yielded the desired success. Only the use of the atmospheric-pressure plasma technique developed in Germany met all the environmental, safety and efficiency requirements. According to Yves Pelpel, "With its system technology Plasmatreat has created a solution which allows the surface treatment needed for the Triplex bonding processes directly under best conditions on the construction site."

Plasma - the "fourth state of matter" - is the name given to matter at a highly unstable energy level. Energy input via the solid, liquid and gaseous states of matter always takes place in the form of heat. However, plasma technology does not stop at the gaseous state of matter: when additional energy is injected into matter by means of an electric discharge the electrons in it are given higher kinetic energy and leave their atomic shells. Free electrons, ions and fragments of molecules are formed. This state, however, can hardly be used under normal atmospheric pressure conditions due to its instability. Only the "Openair" atmospheric pressure plasma process developed by the German system developers, Plasmatreat, opened up new possibilities for industrial applications.

Neutral plasma

A special feature is that the emerging beam of plasma is electrically neutral. This greatly extends and simplifies its range of applications. Depending on the power supplied and the configuration of the plasma source the temperature of the emergent plasma amounts to up to 300 °C. This allows very high treatment speeds with optimum effects. Typical increases in temperature, of plastic surfaces for example, during treatment are less than 20 °C. The end result is that activation of the surface takes place, which has a very positive effect on adhesion.

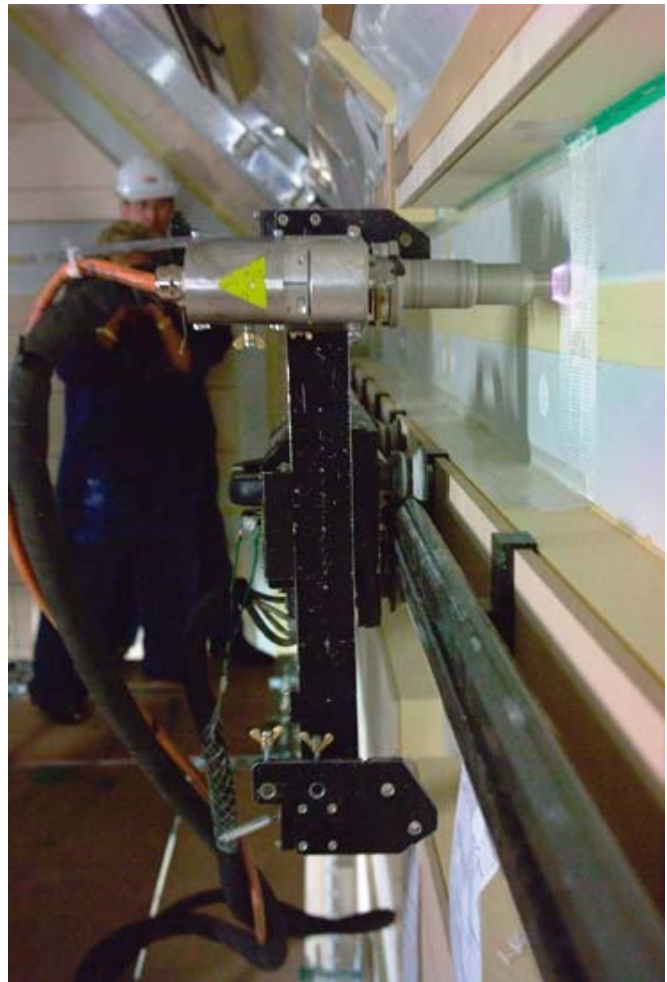
In the process of discharging on surfaces the "Openair" system provides cleaning effects which by far surpass those of conventional systems. Here the user exploits the high electrostatic discharge effect of a free beam of plasma. This effect is further enhanced by the very high speed at which the plasma streams out. As a result of this loosely adhering particles are also stripped away.

The pretreatment solution consisted of the use for the first time on large-area surfaces of a rotating jet integrated into the robots. This jet generates plasma without any risk of overheating. First of all members of staff position a 3 metre long auxiliary rail for the robot in front of the area to be worked on. After the starting point and finishing point have been programmed the robot controls the exact sequence of operations of the jet at guides it completely automatically at a speed of six metres per minute and at a distance (from jet head to surface) of ten millimetres over the surface to be treated. The plasma exercises a double action on the Triplex polymer. On the one hand, the ultra cleaning process destroys all organic substances on the surface, for the plasma beam strikes the surface at a speed of 200 metres per second. On the other hand, the treatment activates the surface tension of the treated surfaces to 72 millinewton per metre. At the end of the operation the auxiliary rail is dismantled and set up afresh at the next area to be treated.

High manpower

In the second step another team of workers carries out the actual bonding process, that is to say the surfaces treated with Openair Plasma are now glued over with Triplex strip. The costs incurred by the shipyard can be measured on the basis of the manpower employed: three hundred workers specially trained in the production of this insulating layer worked round the clock in three eight hour shifts and in one week produced up to 3.5 kilometres of bonded strip.

Since its discovery in 1995 atmospheric-pressure Openair Plasma technology has opened up numerous novel applications in industry, in particular in cleaning, activation and coating processes. At the same time savings in material and process costs as well as the possibility of making environmentally friendly composites are objectives which are very much to the fore. The technology developed by Plasmatreat also accounts for the company's worldwide expansion in just a few years. Another special feature worthy of note is that, whether they are used in an injection moulding machine or a imprinting machine, in a bonding or varnishing plant, the jet systems are always employed in-line, that is directly in the assembly line.



A robot guides the plasma jet over the surface to be treated which will then have the flexible Triplex strip bonded over it

"The Openair system is without any restrictions capable of in-line integration and compatible with robots. By using Openair Plasma as opposed to conventional methods, we have also succeeded in decisively rationalising processes such as the removal of mould release agents from PU mouldings" declares Dipl.-Ing. Christian Buske, Managing Director of Plasmatreat GmbH. The stepwise removal of organic layers, paint stripping, the partial removal of metallised deposits prior to bonding, the production of motor car headlights and also the treatment of reflectors are just some examples of the successful in-line use Openair Plasma in cleaning and coating processes.

Reliable and safe

When aluminium surfaces are to be bonded plasma achieves reliable joints with the most varied aluminium alloys and completely replaces high-cost and ecologically dubious wet chemical processes. The plasma process is absolutely safe for the environment. Precision pretreatment of surfaces to be bonded by the highly developed plasma jets allows the use equally of modern solvent-free UV adhesives and of natural, water-based systems. Thus, for example, after pretreatment with Openair Plasma polycarbonate windows can be glued into the housing half shells of mobile telephones by means of solvent-free UV adhesives. But equally well, casein adhesives can be used for labelling plastic drums.

With its innovative key technology the medium-sized company Plasmatreat today has a presence not only in the most important industrial markets, but also in the most important industrial countries in the world through its twelve international offices.

By Inès Melamies

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